Dynamic Behavior

These recommendations are the second half of the Power Control User Interface Standard. The first was focused on static parts of the user interface and is necessary background for these. This part addresses how devices behave over time. The principles are in brief:

- Use "power up" to mean turn on or wake up, and "power down" for turn off or go to sleep.
- Use flashing green on the power indicator for powering up and flashing amber[1] for powering down.
- Provide optional audio indications for power state transitions.
- Alternating green/amber can be used to mean error if red is not available.
- The power button toggles between the two most common power states.
- When a device is *asleep*, pressing the power button will (usually) wake it up.
- Holding down a power button for an extended time will trigger an emergency action.
- Usually, when a device is *asleep*, the input causing a wake event should be discarded.
- Provide icons to show what types of input may be active.

Below is a more detailed discussion of each principle. There are additional principles that could be established for particular types of devices only, but none are discussed here. Often these will be conventions for expectations of functionality in different power states. For clarity, device states — *on*, *sleep*, and *off* — are shown in italics.

Terminology

Use "power up" to mean turn on or wake up, and "power down" for turn off or go to sleep.

Up is commonly associated with *on* for light switches[2], in English language (e.g. "power up" and "power down"), and in mechanical devices such as hard disks and airplane engines (that "spin up" or "spin down"). Vertically oriented rocker switches for power are also usually up for on. Combination power/volume controls are "turned up" to turn them on and "down" to turn them off[3].

Transitions Indicators

Transitions within a basic state (e.g. for a printer, from actively printing to just *on*, or for a computer from one sleep state to another) need not be indicated. Thus, there are five expected

[1] As in other documents describing this standard, the terms "amber", "yellow" and "orange" are taken as synonymous. What specific colors are best to use will be described in a forthcoming discussion of color.
[2] An exception England and Ireland (and perhaps other countries) where light switches by convention are switched down for *on*.
[3] Further, when a person is standing up they are generally awake, and when sleeping, generally lying down. However, devices should not be anthropomorphized, since that might suggest that "*off* = dead".

transitions that might occur: *off* to *on*, *on* to *off*, *sleep* to *on*, *on* to *sleep*, and *sleep* to *off*[4]. Devices with no sleep state would only have the first two transitions.

Some transitions are nearly instantaneous; below some duration (perhaps a second), they can be considered to be so. For longer transitions, there is a beginning, an end, and the time in the transition, The time in transitions is between the normal power states, so many characteristics true of a basic state will not be true for the transition, such as power consumption, responsiveness, etc. For some devices, there may be some ambiguity about a precise point at which it is fully on.

In some computer environments, it is not always apparent to the key parts of the system when a transition has begun or ended, and the ability to control desired indicators might not be present. For example, for a PC running Windows, the BIOS is not informed when a turn-on or wakeup process has completed—a problem if the BIOS controls the indicator. Also, audio devices may be discovered and configured by the system only partway through the turn-on process, and so unavailable at the beginning of it. Configuration information may also be unavailable until partway through the power-up process, such as the fact that a user has put a device into "silent" mode while in a meeting. All of this leads to the likelihood that many systems will fall short of the ideal transition behavior, at least for the foreseeable future. They can, however, be designed to work incrementally towards the ideal.

A signal indicating when a transition has completed can help the user know when a machine is available for use, or when it can be moved, unplugged, or even opened up for hardware changes.

Some important issues are beyond the scope of this discussion such as what to do with presses of a power button or other input *while already in* a transition state.

Use flashing green on the power indicator for powering up and flashing amber for powering down

These are already used on some products. For example, many printers and copiers will flash an indicator (though often a "ready" indicator) while warming up, and some projectors flash the power indicator while the lamp is cooling (the fan runs during this time). As the transition is a temporary state, the flashing should not be unduly distracting. The beginning of the flashing is also a visual confirmation that the transition has begun. A quick "blink" at the end of a transition could ensure that it is clearly marked.

Flashing rates are discussed by IEC 73: Basic and safety principles for man-machine interface, marking and identification – Coding principles for indication devices and actuators. IEC 73 specifies "normal flashing" as between 1.4 Hz and 2.8 Hz with the on and off times about equal. However, it notes that higher flashing rates should be used for indications of higher priority, and as normal power state transitions might not be considered a high priority and so merit a slower flashing rate. When two flashing rates are used, the slower is to be between 0.4 Hz and 0.8 Hz.

Provide optional audio indications for power state transitions

Audio indications can be helpful for anyone as confirmation that transitions are occurring, particularly if there is no visual indicator, or it is out of sight. For the visually impaired, audio indications can be essential. Silence can be desirable in some circumstances, so audio indications should be able to be turned off.

[4] A device going directly from *off* to *sleep* is certainly possible, but likely to be rare. Usually it will be turned on to perform some action, and so enter the *on* state, at least briefly. Some devices may enter *on* briefly while transitioning from *sleep* to *off*, but not in a way that needs to be shown to the user.

There are at least three types of relevant audio indications: clicks/beeps, tones, and sounds. A click/beep has no elaboration to it other than volume. A tone can be of varying pitch and length. A sound is anything else. Any of these might be used by a device for indicator power transitions.

The first convention is when only simple clicks/beeps are available or used. Elevators use one beep for going up and two beeps for going down (this was developed for use by the blind, but can be useful for anyone). Combining this with the power up/down convention leads to one click/beep for going to *on* and two for going to *off* (the two being identical). To put *sleep* into this scheme would require three clicks, or perhaps two in rapid succession.

Secondly, when tones are available, then powering up would be a rising tone or two tones with the second having a higher pitch than the first. Powering down would be the reverse. *Sleep* can be accommodated in this by using a smaller pitch difference between the two tones than is used for the *on*/*off* transitions.

Finally, when arbitrary sounds can be produced, devices could say words such as "Power On" or "Sleep", though this is not accessible to non-English speakers and could be annoying in most circumstances.

Alternating green/amber can be used to mean error if red is not available

Some devices are only infrequently in error modes, such as a computer monitor that is receiving data faster than it is capable of displaying it. Red is to be used if there is any question of safety, so green/amber should not be used when safety is involved. Many current uses of red do not involve safety, such as paper jams in imaging devices. At least one existing device uses alternating green/amber for a mild error condition, and red for a more significant one.

Power (Sleep) button behavior

Power button toggles between two most common power states: for some devices on/off*; for others* on/sleep

When a device is asleep*, the power button will (usually) wake it up*

A power *switch* moves among two (or more) states, and the switch position indicates the system state. The rocker switch is the most common type used for power switches. A power *button* simply triggers an event when pressed that is then interpreted by the connected hardware. In recent PCs the signal is simply passed on to the operating system which can do processing before sending its own power down signal to the BIOS and hardware. There are three basic cases:

- A device that is only *on* or *off*, in which case the power button's function is clear.
- A device that has three states and both a power and sleep button will use the power button to switch to *off*.
- A device that has three states but is rarely switched off — this is the most challenging case. Some of these might have a "main" power switch, generally a rocker switch, to go to *off*, or may have software means to switch to the *off* mode. A TV with EPG (electronic programming guide) functions that operate during *on* or *sleep* will have a power button (usually on a remote control) that toggles between *on* and *sleep*.

These cases do not apply to rocker switches that control power, as even when their position can be moved by the device mechanically, or if they have an intermediate (sleep) state, the switch position moved to is always clear physically.

An alternate design would specify a different symbol for on/off toggling than the symbol used for on/sleep toggling. One disadvantage is that a difference is imposed on the user when the mental model they are using for the action (power up/down) does not require it. Another disadvantage is that buttons that have behavior that is programmable or that may vary depending on context (e.g. whether connected to AC power or running on battery) can't be labeled properly.

There is one exception to the last principle (that the power button in sleep wakes) —the computer monitor. The reason that the power button turns it *off* when it is *asleep* is that the wake event always comes from the PC, not via the monitor itself. Eventually, if monitors gain their own independent capability to wake up and/or incorporate input devices, then they should become "ordinary" by having the power button wake it up rather than turn it off.

Holding down a power button for an extended time will trigger an emergency action

When a device is malfunctioning and normal procedures do not work, holding down the power button for a much longer time than a normal button press. For existing products that use this functionality, typical times to hold down the button for the emergency action are four or five seconds.

Wake Events

Usually, when a device is asleep, the input causing a wake event should be discarded

The main reason for this is that the meaning of the input may depend on the device state in ways not visible when it is *asleep* (e.g. what application will receive it, or what content is on a touch screen). Also, the user might be unfamiliar with the device and so want to peruse the controls before taking an action. Also, some hardware devices may not be able to properly recognize the wake event, e.g. if it is voice or pen input when it occurs, only that it happened.

However, some actions that wake a machine may be readily executable so this principle should not be seen as universal. For example, hardware-labeled keys that provide clear action (e.g. an eject button). A non-acting wake event should always be provided in addition.

Provide icons to show what types of input may be active

At one time, computers had only keyboards as input devices. In future there will be many possible types of input that a computer or other device might be capable of. In many cases it will be helpful to indicate to the user what is available, particularly for those such as touch and voice that may not be readily visible in the way that a keyboard is. Some possible input devices are: keyboard, mouse, touch-screen, other forms of touch, presence, pen, voice, gestures, remote controls, wired network connections, infrared links, radio (e.g. Bluetooth) links, wireless links, and radio frequency passive transponders.

For some of these, there are already established icons through convention (e.g. Bluetooth). For others, icons will need to be created. These could be printed on devices, shown on screens, or used with indicator lights to show that the input mode is available. This standard does not specify the standard input icons.

On some devices, it may be important to have indicator lights for input availability. The user may not know what inputs are present, and which are operating may change. For example, it may be important to disable some inputs for wake when not wanted, e.g. proximity sensing for a monitor when it is to stay off. Some input devices may take considerable energy to maintain and so undesirable in long-term low-power states; others such as voice might require data processing and so would keep at least part of the device awake.